1up.

"Made available under NASA sponsorship
In the interest of early and wide dissemination of Earth Resources Survey
Program information and without liability
for any use made thereof."

E7.4-10.403
CR-137237

STUDY OF TIME LAPSE PROCESSING
FOR DYNAMIC HYDROLOGIC CONDITIONS

Sidney M. Serebreny
Stanford Research Institute
333 Ravenswood Avenue
Meno Park, California 94025

16 March 1974
Type II Progress Report for the
Period: 6 September 1973 - 6 March 1974

Prepared for

Goddard Space Flight Center
Greenbelt, Maryland 20771

(E74-10403) STUDY OF TIME LAPSE PROCESSING FOR DYNAMIC HYDROLOGIC CONDITIONS Progress Report, 6 Sep. 1973 - 6 Mar. 1974 (Stanford Research Inst.) 17 p HC $4.00 CSCL 08H G3/13

N74-19939

Unclas
00403

TYPE II PROGRESS REPORT

A) Title: STUDY OF TIME-LAPSE DATA PROCESSING FOR DYNAMIC HYDROLOGIC CONDITIONS

B) ERTS-A Proposal 342-B GSFC ID PR154

C) INTRODUCTION

Under ERTS-A Proposal 342-B SRI has been charged with demonstrating and further exploring the use of electronic techniques in converging upon quantitative descriptions of hydrologic and hydrologic-related phenomena of satellite imagery obtained from the ERTS satellite. The efforts have been directed toward the specific data processing needs of a group of ERTS principal investigators within the U.S. Geological Survey (Water Resources Division) operating in widely diverse specialities but all part of the Water Resources Division Program in Dynamic Hydrology. This is a report of that effort accomplished between 6 September 1973 and 6 March 1974.

D) PREVIOUS AND CURRENT ACTIVITIES

1. Hardware

The required modifications and additions to ESIAC have been completed. The three important additions to the ESIAC circuitry reported in the previous Type II report (viz, capability for grey-scale storage on same video disc track as main image, the semiconductor binary memory mask store (scratchpad memory) and the two-dimensional color space display) are working satisfactorily and have been used in the data measurements for the participating investigators made during this period.

2. Data Processing

The following data processing activities and techniques undertaken for the participating investigators can be reported:

- For Dr. M. F. Meier (INO 45), U.S. Geological Survey, Tacoma, Washington.

Work was completed on the assessment of snow amounts on Mt. Rainier, using the contour-elevation technique described and illustrated in the previous Type II Progress Report. With this technique, the contour elevations are used as masks (made in 1000 ft or 500 ft increments) to fit over the snow limit. Since no one elevation, in general, will fit the snow field in all areas it was necessary to subdivide the Mt. Rainier region into three pie-shaped sectors, match the snow line in each, evaluate each area and then total. This evaluation has been completed for cycles 0, 2, 4, 6, 7, 14, 15, 16, 17, and 18.

Snow coverage was measured in ten selected basins within the Cascades range in the State of Washington (see Figure 1) for the period of ERTS data which extended from 29 July 1972, Cycle 0, through 15 September 1973, Cycle 23.

Table 1 lists the number of cycles for which one or more basins could be evaluated and shows that for any basin a maximum of ten cycles and a minimum of 6 cycles were available for evaluation.

Measurement Procedure

To estimate snow coverage for any particular cycle and basin, the procedure was to generate a binary mask of areas with a technique termed "radiance-above-threshold" using the MSS-5 image. The threshold was varied to obtain the Best Visual Estimate (BVE) of the binary mask to the areas subjectively determined to be snow in the full tone scale Band 5 image. All measurements were made by performing the thresholding

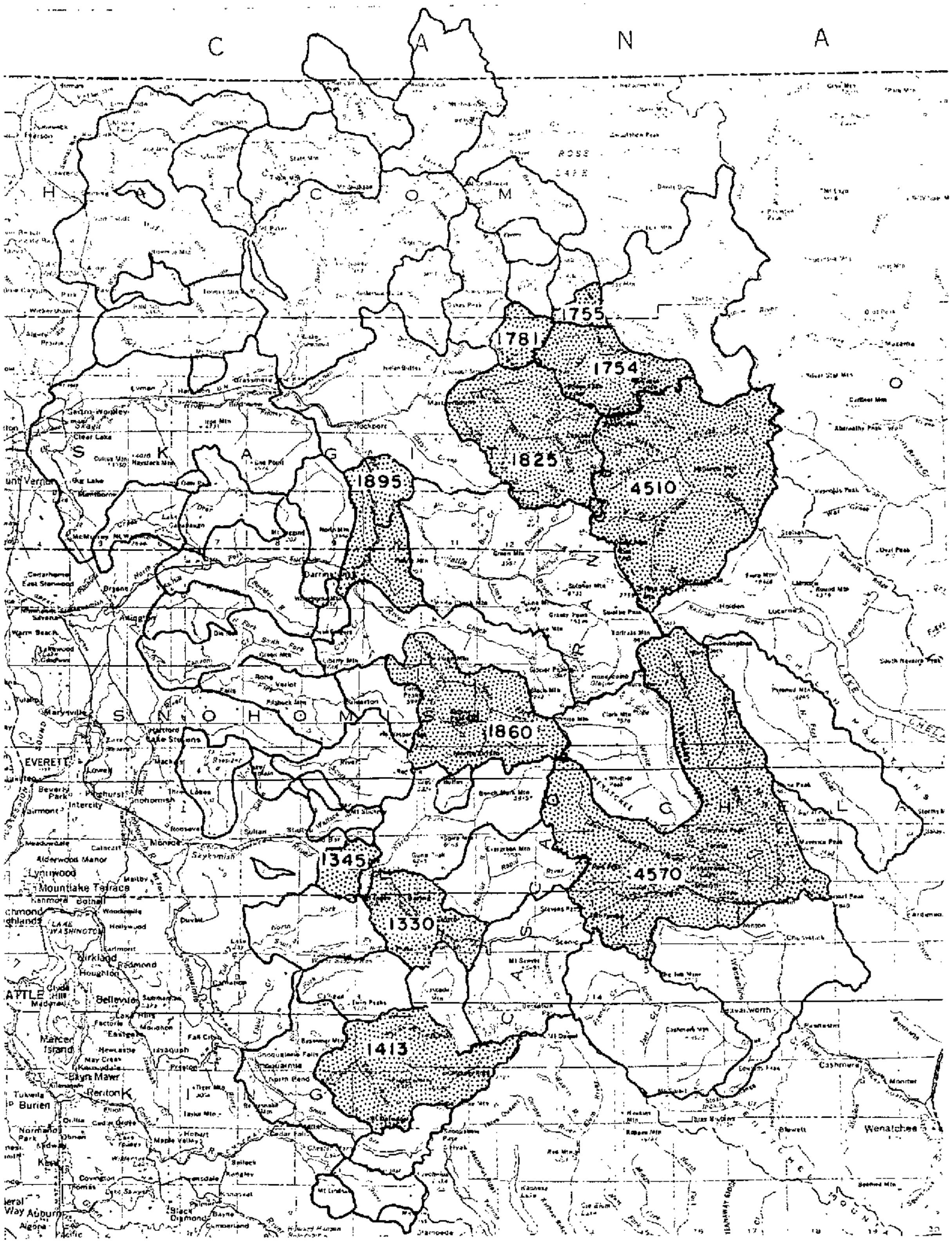


Figure 1 BASIN LOCATIONS

Table 1 List of Cycle Numbers for Which One or More Basins Could be Evaluated*

Date	Cycle No.	Basin 1330	1345	1413	1755	1781	1825	1860	1895	4510	4570	Total Basins
1972												
29 July	0	x	x	x	x	x	x	x	x	x	x	10
16 Aug	1	---	---	---	---	N/A	---	---	---	---	---	0
2 Sept	2	x	x	x	x	x	x	x	x	x	x	10
20 Sept	3	---	---	---		Area	Cloudy	---	---	---	---	0
8 Oct	4	x	x	x	x	x	x	x	x	x	x	10
26 Oct	5	- cloudy		---	---	N/A	------	cloudy	------N/A	→	cloudy	0
14 Nov	6	x	x	x	←	cloudy	→	x	x	cloudy	N/A	5
12 Dec	7	---	---	---		Area	Cloudy	---	---	---	---	0
20 Dec	8	---	---	---	---	N/A	---	---	---	---	---	0
1973												
6 Jan	9	x	x	x	----	N/A	----	x	---N/A	------	x	5
25 Jan	10	---	cloudy	---	----	N/A	----	cloudy	---N/A	------	cloudy	0
12 Feb	11	---	cloudy	---	x	cloudy	x	--- cloudy	--	N/A	cloudy	2
2 Mar	12	---	---	---	---	N/A	---	---	---	---	---	0
20 Mar	13	---	---	---	---	N/A	---	---	---	---	---	0
7 Apr	14	x	x	x	x	x	x	x	x	-----N/A	--------	8
25 Apr	15	x	x	x	x	cloudy	x	x	x	-----N/A	--------	7
12 May	16	---------	N/A	------	x	x	x	N/A	x	x	N/A	5
30 May	17	x	x	x	x	x	x	x	x	x	x	10
18 Jun	18	---	cloudy	----	----	N/A	----	cloudy	----	N/A	----	0
6 July	19	---	---	---	---	N/A	---	---	---	---	---	0
24 July	20	---	---	---	---	N/A	---	---	---	---	---	0
11 Aug	21	x	cloudy	x	x	x	x	x	x	← N/A	→	7
29 Aug	22	←	N/A	→	←		cloudy		→	← N/A	→	0
12 Sept	23	x	x	x	x	x	x	x	x	x	x	10
Total Cycles		10	9	10	10	8	10	10	10	6	6	

*x = Measured
N/A = No Data

operation on the Band 5 signal. However as an interpretative aid to the operator, one good two-color image (usually Bands 5 and 6) was entered for each basin. All images were carefully registered to each other and to the basin outline. Thus time-lapse comparisions were also possible, and provided some help in estimating the location of the snowline, particularly through depiction of changing shadow effects.

Since the determination of the Best Visual Estimate is subjective, it was deemed valuable for the analyst also to derive (with 85% confidence) the area range within which the true snow coverage is likely to exist in his opinion. Procedurally, having derived the Best Visual Estimate, the analyst then raises the threshold until he has reached an 85% confidence that the true snow coverage is greater than this threshold. In so doing the mask shrinks to cover only the brighter elements and the mask need not be varied too much before the analyst reaches this confidence. Conversely, the operator then lowers the threshold in order to encompass the less bright elements that may or may not be snow until he has reached an 85% confidence (admittedly subjective) that the true snow coverage is less than this lower threshold coverage. This range from "minimal extent" to "maximum extent" about the Best Visual Estimate has been termed the "estimation spread" and recorded as area values along with the Best Visual Estimate. The Best Visual Estimates, together with the probable limits of snow coverage, constitute the measurements taken in this work task.

RESULTS

1. Best Visual Estimates

Plots of the best visual estimates values of the snow coverage for the 10 selected basins are presented as Figure 2 (expressed in sq km) and Figure 3 (expressed as a percent of the total basin area). [Note: The estimation spread is not shown on these figures.] Despite

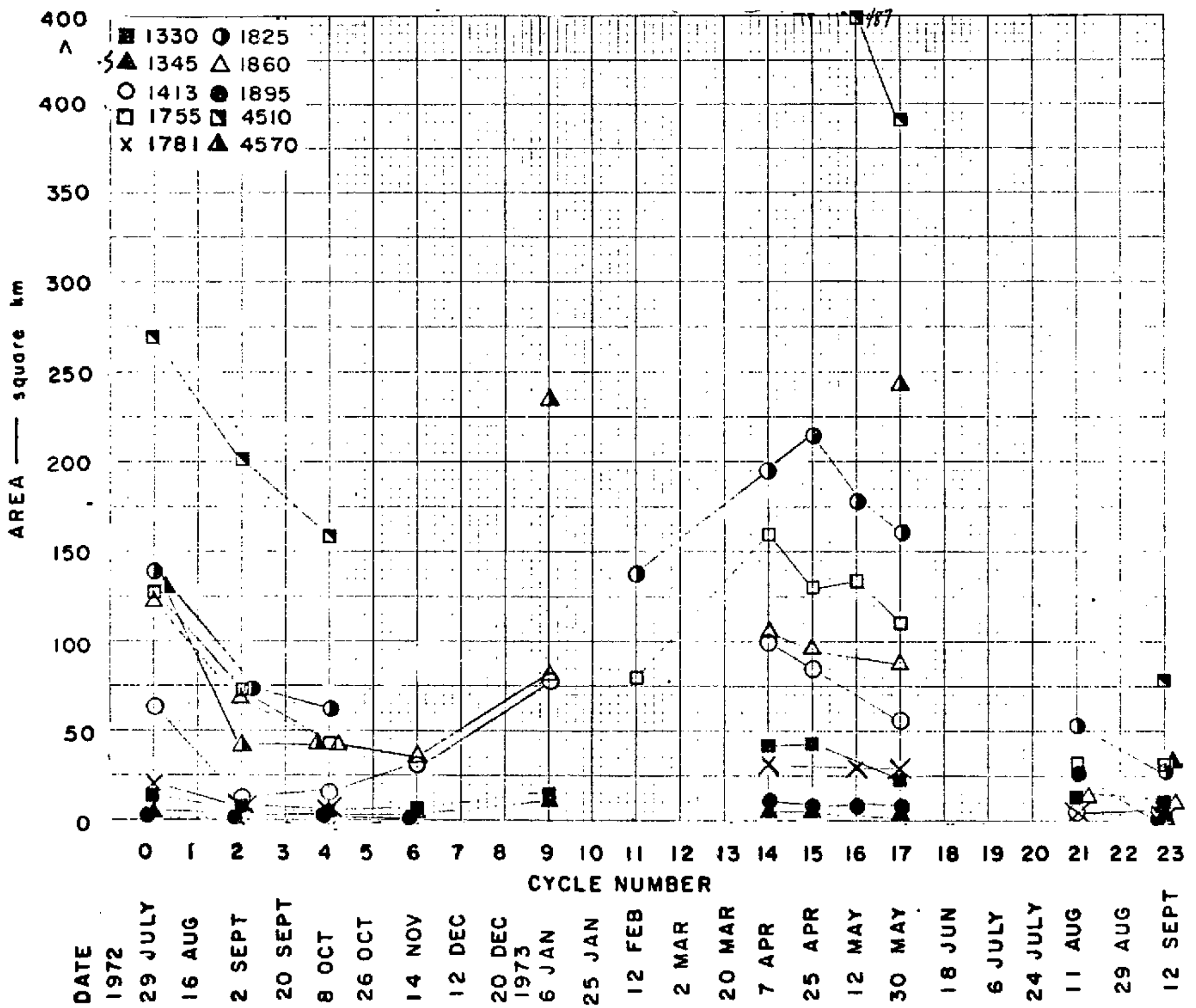


FIGURE 2 ABSOLUTE AREA VALUES (sq km) - BVE SUMMARY

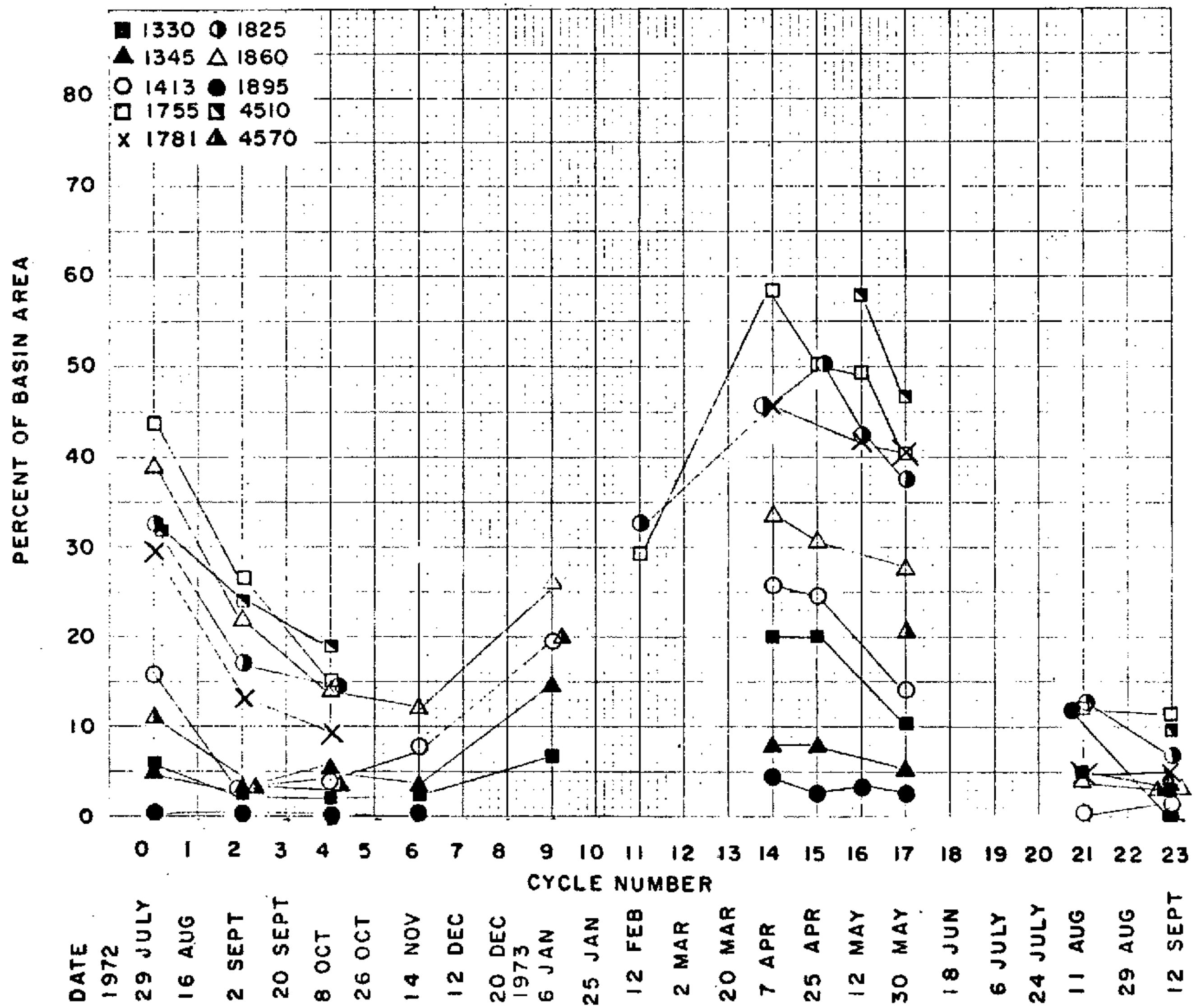


FIGURE 3 PERCENT OF BASIN AREA COVERAGE - BVE SUMMARY

the loss of data coverage through the year, a reasonable delineation of the temporal and spatial changes in snow coverage is discernable. A definite cyclic fluctuation of the snow coverage occurs in all basins through these 23 cycles. A defined minimum in coverage is seen by cycle 4; this minimum may extend through as long as cycle 7, certainly through cycle 6. The maximum coverage seems to occur at cycle 14, but it may have occurred as early as cycle 12. A return to minimum coverage is indicated from cycle 21, through cycle 23, although it may have occurred as early as cycle 20.

2. <u>Estimate Spread</u>

As a general rule, where the snow coverage was sparse the spread was also small, even on a percentage basis--there is just little or no lee-way variation in the estimation of maximum and minimum snow coverage about the Best Visual Estimate.

Also, during periods of minimum snow coverage, the remaining snow patches tend to be grouped in a small area, reducing the effect of spatial differences. During periods of greater snow coverage, the spread tends to become larger even in a relative sense. In these situations the snow coverage patterns were more likely to be dendritic.

3. <u>Radiance</u>

Figure 4 is a plot, by cycles, of the threshold grey step value coinciding with the Best Visual Estimate of snow coverage. The same cyclic fluctuation that was seen in Figure 2 is apparent here, as well. Where snow coverage is minimal (cycles 4-6) the grey step values vary between 2 and 5 - at the time of maximum coverage and highest sun angle (cycles 14-17) the grey step values vary from 7 to 10.

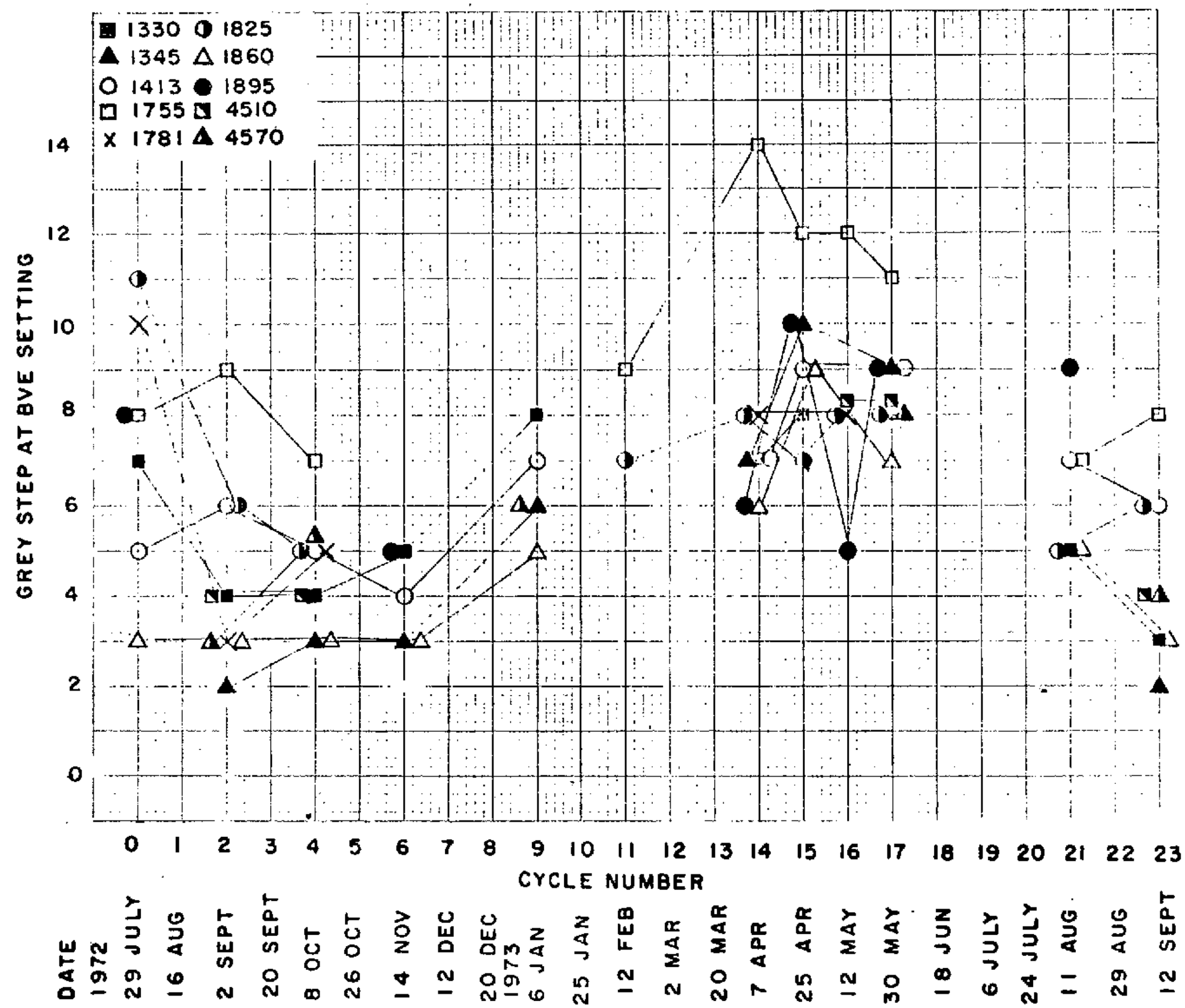


FIGURE 4 GREY STEPS RESULTING FROM USE OF BVE

- For Dr. R. M. Turner (IN 411), U.S. Geological Survey, Tucson, Arizona.

Dr. Turner visited SRI during the week of 25 February - 1 March 1974 for the purpose of obtaining measurements of vegatation cover over his test sites (Tucson, Arizona and surrounding territory) for additional ERTS cycles. Registered color sequences for these ERTS cycles were prepared for two major sites entitled "Tucson" and "Avra Valley". Thematic masks created by counting all picture elements were the Band 6/ Band 5 radiance ratio exceeded 1.25 were the means whereby the vegatation cover was evaluated.

1. Results

The results were as follows:

Tucson Scene

	Sliced Area (km^2)	Total Mask Area (km^2)	% of Total Mask Sliced
Cycle 17	788.3	24,467.1	3.2
Cycle 19	765.0	24,043.8	3.2
Cycle 23	2099.3	23,255.5	9.0
Cycle 27	458.4	20,730.0	2.2

Avra Valley Scene

	Sliced Area (km^2)	Total Mask Area (km^2)	% of Total Mask Sliced
Cycle 2	500.9	2,244.8	22.3
Cycle 10	22.2	2,076.1	1.1
Cycle 11	34.8	1,788.1	1.95
Cycle 15	113.8	2,243.5	5.1
Cycle 17	221.0	2,188.6	10.1
Cycle 18	138.0	2,164.5	6.4
Cycle 19	28.5	2,144.4	1.3
Cycle 23	40.7	2,183.2	1.86
Cycle 27	8.0	2,130.1	0.37

In addition, color photographs (35 mm) were taken of all cycles available to date for "Tucson" and "Avra Valley".

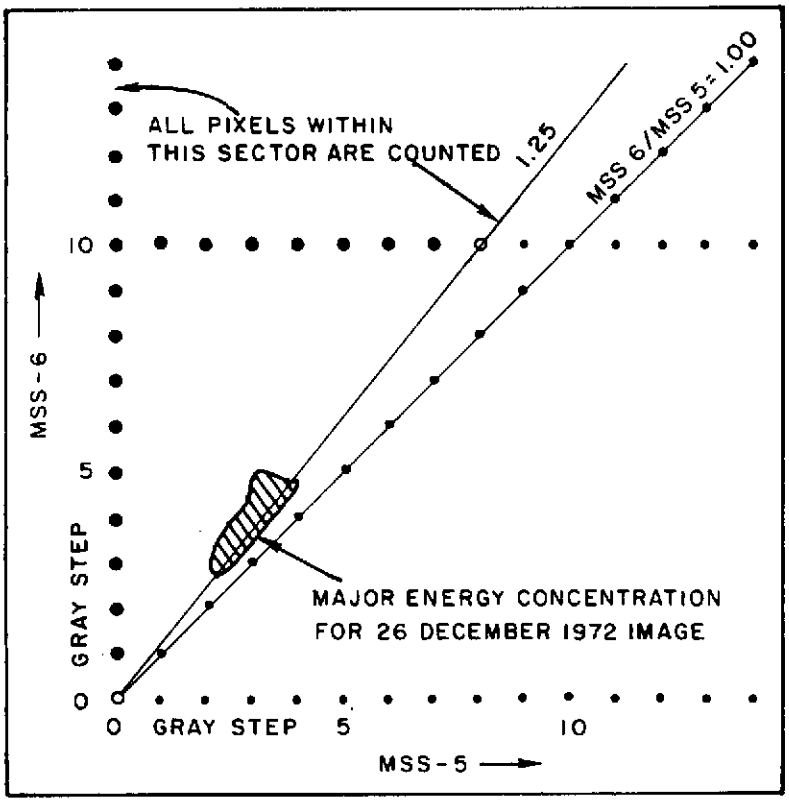
Wave-form traces of the grey scales (Band 5 and 6) and transects through the "South Mine" in the Tucson scene (imagery) for cycles 17, 19, 23 and 27; as well as grey scales (Band 5 and 6) and transect through the "Piano Mine" in the Avra Valley scene (imagery) for cycles 2, 10, 11, 15, 17, 18, 19, 23 and 27 were also supplied.

2. Ratioing Using the Two-Dimensional Color Spacing Display

A description of the TWO-DIMENSIONAL COLOR SPACE DISPLAY was given in the Appendix to the previous Type II Progress Report.* Briefly, the display is an oscilloscope with matched wideband x and y deflection amplifiers and is used in conjunction with an ERTS image generated on the TV monitor using some combination of visible and infrared bands. While the TV display is being scanned in normal TV raster fashion, the spot on the x-y oscilloscope is being continuously positioned in accordance with the instantaneous responses in the two image channels. All points in the TV image which generate equal responses in the visible and IR channels will be distributed ("mapped") along a 45° diagonal line in the oscilloscope display. Zero response is located at the origin in the lower left corner. The visible and infrared bands (grey scales) used will appear as a series of dots comprising the horizontal and vertical axes, respectively through the origin.

A sketch of the color space display of a desert scene plus its calibration grey step is shown in Figure 5. Note that to facilitate adjustment of the ratioing controls a second row of Band 5 grey scale calibration dots has been located to intersect the Band 6 grey scale

*STUDY OF TIME LAPSE PROCESSING FOR DYNAMIC HYDROLOGIC CONDITIONS Type II Progress Report for the Period: 6 March - 6 September, prepared for Goddard Space Flight Center, Greenbelt, Maryland 20771, by Sidney M. Serebreny, Stanford Research Institute, Menlo Park, California.



a) Sketch of Color-Space Display set to a Band 6/Band 5 ratio of 1.25:1

b) Binary Mask Resulting from Band 6/ Band 5 ratio of 1.25:1

Figure 5 EXAMPLES OF SLICING DISPLAYS, CYCLE 9, 26 DECEMBER 1972, - AVRA VALLEY, ARIZONA at step 10. With the ratioing and thresholding properly set, and the display intensified with the resulting thematic mask video signal, only those regions above and to the left of a diagonal line between the origin and grey step 8 on this auxiliary calibration axis will be displayed (and counted) for this ratio of 1.25.

- For Dr. C. C. Reeves (IN 168), Texas Tech University, Lubbock, Texas.

Per letter request from Dr. Reeves, the water and/or mud content of North Playa of the Double Lakes region was re-evaluated for dates of 29 July 1972 and 12 February 1973. These results were forwarded to Dr. Reeves on 29 November 1973. The final edited version of the film loops showing the Double Lakes area was delivered to Dr. Reeves at the NASA Conference, held November 1973. No further work was processed during the period covered.

- For Dr. E. J. Pluhowski (INO 58), USGS-WRD, Arlington, Virginia.

No work was processed for Dr. Pluhowski during this period.

- For Dr. F. Ruggles (IN 395)

Dr. Ruggles visited SRI on 10 November 1973 and personally completed data measurements and interpretations from static scenes, as well as time-lapses sequences on 10 November 1973.

- For Mr. E. Hollyday (IN 389) USGS-WRD, Nashville, Tennessee.

No work was processed for Mr. E. Hollyday during this period.

E) FUTURE PLANS

1. Equipment

No significant additions or modifications to ESIAC are planned for the next reporting period.

2. Data Measurements

- For Dr. M. Meier

Work will continue on the evaluation of basin snow. In addition, an evaluation of spectral signature of ice and snow and the snow coverage on the Olympic Peninsula plus the evaluation of glacial surges, is expected to be underway.

- For Dr. R. Turner

Enter scenes for "Sabino Canyon" and "Benson" sites for all available cycles (16) and slice at 1.25/1 ratio.

a) compute areas

b) photograph slices - Polaroid black/white

c) take 35 mm color photographs of cycles

- For Dr. C. C. Reeves

No additional work has been planned for the next period.

- For Dr. E. Pluhowski

Dr. Pluhowski plans to spend May 7th - 9th, 1974 at SRI for imagery analysis.

- For Dr. F. Ruggles

No additional work is anticipated during the next period.

- For Mr. E. Hollyday

No additional work is anticipated during the next period.

F) VISITS AND PRESENTATIONS

- Mr. S. M. Serebreny presented a paper entitled "ESIAC, A Data Products System For ERTS Images" at the Third ERTS Symposium sponsored by NASA/Goddard Space Flight Center held in Washington D.C. at the Statler-Hilton Hotel from December 10-14, 1973. The paper presented in the section on Interpretation Techniques also included a short movie demonstrating some data processing capabilities of the ESIAC. The abstract of this paper follows:

ABSTRACT

An Electronic Satellite Image Analysis Console (ESIAC) has been developed for visual analysis and objective measurement of Earth Resources Imagery. The system is being employed to process imagery for use by USGS investigators in several different disciplines studying dynamic hydrologic conditions. The ESIAC provides facilities for storing registered image sequences in a magnetic video disc memory for subsequent recall, enhancement, and animated display in monochrome or color. The unique feature of the system is the capability to time-lapse the ERTS imagery and/or analytic displays of the imagery. Data products have included quantitative measurements of distances and areas, brightness profiles, and movie loops of selected themes.

The applications of these data products are identified and include such diverse problem areas as measurement of snowfield extent, sediment plumes from estuary discharge, playa inventory, phreatophyte and other vegetation changes. A short movie is presented to demonstrate some uses of time lapse presentation that have been employed in these investigations. A comparative ranking of the electronic system in terms of accuracy, cost effectiveness and data output shows it to be a viable means of data analysis.

- Mr. W. E. Evans plans to present a paper entitled "Progress In Measuring Snow Cover From ERTS Imagery" at the Western Snow Conference, Anchorage, Alaska, to be held April 16-20, 1974. The Abstract of this paper follows:

ABSTRACT

A hybrid of digital and analog analysis techniques are being employed to determine the accuracy with which snow area and temporal change in snow area can be determined from ERTS satellite imagery.

The principal analysis tool is an Electronic Satellite Image Analysis Console (ESIAC) which permits display of time-lapse sequences of color composite images on a color TV monitor. Binary snow maps are generated electronically, superimposed on the image display for any

necessary human editing, then measured for area in a digital counter. Results are checked against high altitude aircraft photography.

Bright snow is relatively easy to measure. Snow in shadow or illiminated at low incidence angles is harder to identify unambigously. Several potential solutions for this problem and for the problem of snow-tree mixtures are being studied. A time-lapse movie showing a full year of ERTS imagery of a typical mountain snowfield will be shown.